



QUESTION 7: PURPOSE OF EXPERIMENT

NARRATIVE SUMMARY

SpaceX requests Special Temporary Authority to operate two (2) mobile ground-based Starlink user terminals aboard a maritime vessel while embarked in U.S. territorial waters in the North Atlantic Ocean for a 6 month period beginning 18 July 2022 or the date license is granted. This experiment will enable SpaceX to assess and improve the ability of its systems to provide service to maritime vessels in motion. This live-sky experiment is meant to test and demonstrate the SpaceX antenna as an earth station in motion in new geographic locations and sea states. The terminal used under this authorization will be electrically identical to the terminals currently in use under ELS File No. 0773-EX-CN-2020 from a radiofrequency perspective.

On March 29, 2018, the Commission granted SpaceX's application for authority to launch and operate a constellation of non-geostationary orbit ("NGSO") satellites designed to provide high-speed, high-capacity, low-latency broadband services in the United States and around the world.¹ SpaceX has successfully launched more than 1700 Starlink satellites to date. The Commission has previously granted SpaceX an experimental authorization to demonstrate the ability of SpaceX's NGSO system to transmit and receive information between both fixed sites on the ground and earth stations aboard moving vessels and aircraft.²

Like those previously authorized, the tests requested here are designed to demonstrate the ability to transmit to and receive information from a terminal in motion. Nothing about these experiments will change the operation of SpaceX spacecraft, which will continue to operate as authorized. As discussed below, these proposed operations will not adversely affect any other authorized spectrum user, including geostationary orbit ("GSO") satellite systems.

The Commission has previously granted experimental authority to conduct similar maritime testing in the vicinity of SpaceX launch operations offshore from Cape Canaveral, Florida.³ This test represents a notable incremental increase in the scope of previous tests as this experiment enables a more taxing set of environmental conditions than the relatively nominal sea states suitable for rocket booster recovery operations.

SpaceX will analyze the data link performance and installation options for maritime user terminals. In order to complete the link with its satellites, SpaceX will use gateway earth stations authorized by the Commission for communications with the Starlink system. Communications with the satellites will be limited to a minimum elevation of 25 degrees above the horizon at all times during testing.

¹ See *Space Exploration Holdings, LLC*, 33 FCC Rcd. 3391 (2018). The Commission has since modified that license. See, e.g., *Space Exploration Holdings, LLC*, FCC 21-48 (rel. Apr. 27, 2021) ("*SpaceX Authorization*").

² See Experimental Authorization, ELS File Nos. 0388-EX-CN-2019, 0773-EX-CN-2020 and 0515-EXCN-2019.

³ See, Experimental Authorization, ELS File No. 0773-EX-CN-2020 (granted Feb. 10, 2021).



Table 1 summarizes the technical specifications of SpaceX's proposed earth station terminals. Additional information on terminal performance characteristics can be found in Exhibit 1 of the subject application.

Table 1. Starlink Terminal Characteristics

Link Type	Frequency	Modulation	Emission Designator	Maximum EIRP
Broadband Downlink (space-to-Earth)	10.7-12.7 GHz	Up to 64 QAM	240MD7W	N/A
Broadband Uplink (Earth-to-space)	14.0-14.5 GHz	Up to 64 QAM	60M0D7W	38.2 dBW

Interference Protection

Consistent with SpaceX's space station authorization, this earth station will transmit in the 14.0-14.5 GHz band and receive in the 10.7-12.7 GHz band. The Commission has allocated the Ku-band uplink band (14.0-14.5 GHz) that SpaceX proposes to use for this earth station on a primary basis only to FSS. Certain portions of the 10.7-12.7 GHz downlink band are shared with other commercial and government services. However, because this earth station would not transmit in 10.7-12.7 GHz, it will not cause any interference to other operators in that band. SpaceX has engineered its satellite system to achieve a high degree of flexibility to facilitate spectrum sharing with other authorized satellite and terrestrial systems.

SpaceX is aware of its obligations under its authorization to protect terrestrial and space systems in these shared bands, particularly the applicable equivalent power flux-density ("EPFD") limits set forth in Article 22 and Resolution 76 of the ITU Radio Regulations and the applicable power flux-density ("PFD") limits set forth in the Commission's rules and Article 21 of the ITU Radio Regulations.⁴ The user-terminals SpaceX seeks to operate in this application are planned to be electrically identical with the 1,000,000 user terminals the Commission has previously authorized from a radiofrequency perspective, and, in all events, will operate within that previously authorized user-terminal network within those EPFD limits and will not exceed the on- or off-axis EIRP levels of those devices.⁵ The Commission has found that compliance with these EPFD and PFD limits is sufficient to protect GSO systems and terrestrial systems, respectively, against

⁴ See *SpaceX Authorization*, ¶¶ 97(b), (d), and (e); 47 C.F.R. § 25.115(f)(1) (incorporating certification requirement in 47 C.F.R. § 25.146(a)(2)).

⁵ *Id.* Notably, the Commission does not require the submission of antenna patterns for blanket-licensed NGSO earth stations, as the EIRP mask is sufficient to verify compliance with EPFD limits and other interference-protection benchmarks. SpaceX's Part 25 blanket user-terminal authorization was granted on this basis. NGSO user terminals are also not required to comply with the antenna-gain limitations in Section 25.209. The Commission has granted other blanket user-terminal authorizations as well that have not included antenna patterns and which have correctly asserted that "that the Commission's antenna performance standards contained in Section 25.209 of the Commission's rules are not applicable to NGSO user terminals." See *Radio Station Authorization*, IBFS File No. SES-LIC-20190930-01217 (granted Apr. 27, 2021) (call sign E190727).



harmful interference.⁶ SpaceX complies with these EPFD and PFD limits by enforcing elevation limits, GSO avoidance angles and transmit EIRP masks on its terminals. The experimental earth stations in this application will comply with the same limits as the terminals covered under SpaceX's blanket license.

The EIRP masks for the proposed user terminal type, for co-polarized and cross-polarized signals, are set forth below. In addition, the proposed operations will comply with the FCC's requirements for NGSO Earth Stations in Motion ("ESIMs") in these bands to ensure that motion of the user-terminal will not cause it to inadvertently exceed interference protection limits. In particular, each experimental earth station in the 14-14.5 GHz band will be self-monitoring and, should a condition occur that causes them to exceed EIRP, EIRP density and off-axis EIRP mask limits included in the licensing conditions for the FSS NGSO network that it is using as a point of communication, the experimental terminal will automatically cease transmissions within 100 milliseconds, and not resume transmissions until the condition that caused the experimental terminal to exceed those limits is corrected.⁷

Almost all of the spectrum SpaceX proposes to use in this experiment is available for ESIM use with NGSO FSS systems.⁸ SpaceX recognizes, however, that the 12.2-12.7 GHz band (the "12 GHz band") is not specifically listed among the bands available for ESIM operations. The Commission did not, however, affirmatively prohibit ESIM operations in this band—though it did so with respect to other spectrum.⁹ Rather, the Commission did not include the 12 GHz band because it had not been included in the proceeding and thus "the record is insufficient for us to consider use of these bands for ESIMs communications with NGSO FSS satellites."¹⁰ But to repeat, the proposed earth stations will only *receive* in this band, and thus cannot cause any interference to other authorized users. Moreover, they will operate at sea—well away from potential deployments on land—and the Commission's rules specifically contemplate that

⁶ See, e.g., *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range*, 16 FCC Rcd. 4096, ¶ 77 (2000) (concluding that implementation of EPFD limits "will adequately protect GSO FSS networks"); 47 C.F.R. § 25.289 (NGSO satellite systems that comply with EPFD limits will be deemed not to cause unacceptable interference to any GSO network); *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range*, 16 FCC Rcd. 4096, ¶ 42 (2000) (observing PFD limits should protect terrestrial systems in the band). In addition, pursuant to Section 25.115(i), SpaceX Services hereby certifies that it is planning to use a contention protocol (TDMA/FDMA), and such protocol usage will be reasonable.

⁷ See 47 C.F.R. § 25.228(c).

⁸ See 47 C.F.R. § 25.202(a)(10)(ii).

⁹ See 47 C.F.R. § 25.115(f)(2) (prohibiting ESIM operations in the 28.35-28.4 GHz band).

¹⁰ *Facilitating the Communications of Earth Stations in Motion with Non-Geostationary Orbit Space Stations*, 35 FCC Rcd. 5137, ¶ 46 (2020).



experimental authorizations may be issued for operations inconsistent with existing frequency allocations so long as they are on a non-interference basis.¹¹

SpaceX is confident that the highly advanced and flexible capabilities of its NGSO system, including the earth stations proposed by SpaceX herein, will be able to comply with the limitations discussed above. Nevertheless, in the extremely unlikely event that harmful interference should occur due to transmissions to or from its earth stations, SpaceX will take all reasonable steps to eliminate the interference. Should an issue arise, SpaceX can be reached at:

Starlink Network Operations Center

satellite-operators-pager@spacex.com

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¹¹ See 47 C.F.R. § 2.102(b)(3) (“Experimental stations, pursuant to part 5 of this chapter, may be authorized the use of any frequency or frequency band not exclusively allocated to the passive services” on a non-interference basis).

